REMARKS

Reconsideration is respectfully requested.

By the present amendment, claims 19-21 have been newly added. Claims 19-21 are supported by the application at page 14, 27- 30. ["temperature of 40C... processing conditions may be modified".] Claims 1-18 remain pending in the present application. Claims 1, 5 and 10 are independent claims. Applicants request reconsideration and allowance in view of the foregoing amendments and the following remarks.

35 U.S.C. § 103(a) Rejection based on admitted prior art and Moustaka

1. Claims 1, 3, 5, 6, 8, 10, 11, 13 and 15 are rejected under 35 U.S.C. § 103(a) as unpatentable over *alleged* admitted prior art in view of Moustaka (U.S. Patent No. 5,847,397). Applicants respectfully traverse this rejection.

Independent claims 1, 5 and 10 each recite a method associated with a compound semiconductor layer including nitrogen. Claim 1 is illustrative and recites *inter alia*:

> ...removing part of the compound semiconductor layer by dry etching;
>
> performing a nitrogen plasma treatment step to recover from damage due to nitrogen vacancies arising in a surface of the compound semiconductor layer as a result of the dry etching.

In outline form, the independent claims relate

(1) a dry etching step that attacks a compound semiconductor layer including nitrogen, either by removing part of the nitrogen-containing compound semiconductor layer itself (claim 1) or removing part of an overlying compound semiconductor overlying layer to partially expose the surface of the nitrogen-containing compound semiconductor layer (claims 5 and 10),

followed by;

(2) a nitrogen plasma treatment step to recover from damage due to nitrogen vacancies arising in the nitrogen-containing compound semiconductor layer as a result of the dry etching.

Accordingly, even if the U.S. PTO can use three pages of specification as evidence, it is applicants' view that the three pages lead away from the claims at issue.

The "reasons" in the outstanding Office Action, supporting alleged "admitted prior art" do not appear to treat the description of the specification accurately and thus what the PTO apparently alleges as admitted does not appear in this file or this record, --- except in the expression of the U.S. PTO alleged rejection. The "reference" contains no description that dry etching causes nitrogen vacancies to any surface. The U.S.PTO cites no part of the three pages on which reliance is placed to support the U.S. PTO grounds of rejection.

Specifically, the Office Action advances "which is a problem recognized by one skilled in the art at the time the invention was made." Although The U.S. PTO cites to page 3 of the specification, there is no description therein to support the U.S. PTO allegations. The only expression in the specification is that a reference suggests **that hydrogen plasma treatment might cause certain deficiencies**.

Correction of the misimpression follows: One of the references cited at page 3 of the specification is the paper by Hashizume et al. entitled 'Discrete surface state related to nitrogen-vacancy defect on plasma-treated GaN surfaces'. According to applicants' Japanese representation, this paper offers the following findings and conjectures about plasma treatment.

(a) Treatment of a gallium nitride (GaN) surface with hydrogen (H_2) plasma can cause metallic gallium droplets to appear on the surface, possibly because hydrogen reacts with nitrogen to form volatile compounds such as NH_3, which escape. Their escape leaves the surface depleted in nitrogen and causes a discrete defect state to appear among the electrical states at the surface. This defect state may be an electron-donor state related to nitrogen vacancies (page 4566, left column, lines 14-19 and right column, lines 17-26).

(b) No such effect is observed for a GaN surface treated with nitrogen (N_2) plasma (page 4566, right column, lines 26-27)

(c) Reactive-ion-beam etching of a GaN surface using a CH_3/H_2 gas mixture (a type of dry etching) could introduce a defect state related to nitrogen vacancies (page 4566, left column, lines 26-31).

The only information that an artisan gleans from Hashizume et al. is that ***hydrogen*** plasma treatment might cause nitrogen vacancies. However, there is no evidence to support the occurrence with nitrogen plasma treatment.

Moreover, nothing, is suggested about how to get rid of nitrogen vacancies that already exist, or recover from associated defects.

According to the Examiner, Moustakas teaches a method for reducing or recovering from nitrogen vacancies. Scrutiny of Moustaka reveals that column 5 lines 30 et seq. relied upon by the U.S. PTO recites:

> In a typical process, the substrate 19 is sputter-etched by the nitrogen plasma at about 600.degree. C., for example. Other high temperatures, from about 600.degree. C. to about 900.degree. C., for example, may also be used. This process effects nitridation. Nitridation is a process in which sapphire (Al.sub.2 O.sub.3) is bombarded with nitrogen at relatively high temperatures. The nitrogen replaces the oxygen on the surface of the sapphire and creates atomically smooth AlN. After nitridation, the substrate is cooled down to 270.degree. C. in the presence of the nitrogen plasma. A gallium shutter 23 is then opened to deposit the initial buffer layer of GaN. The use of an activated nitrogen source permits the deposition of GaN at this low temperature. The buffer layer is allowed to nucleate over ten minutes, for example, and then the gallium shutter 23 is closed to stop the nucleation of the film. The substrate is then brought slowly to 600.degree. C. at the rate of 4.degree. C. every 15 seconds in the presence of the nitrogen plasma. The nitrogen overpressure also helps reduce the formation of nitrogen vacancies.

According to the Examiner, Moustakas teaches a method for reducing or recovering from nitrogen vacancies. There is no such description in Moustakas.

In Col. 4, lines 29-49, Moustakas suggests that low-temperature molecular beam epitaxy (MBE) assisted by electron cyclotron resonance (ECR) can be used to grow or deposit a GaN layer with a reduced number of nitrogen vacancies, as compared with higher-temperature growth processes. In Col. 5, lines 39-56, Moustakas suggests that a nitrogen plasma overpressure during the deposition and growth of a GaN layer might help reduce the formation of nitrogen vacancies.

Like Hashizume et al, Moustakas suggests that nitrogen plasma can be used to prevent nitrogen vacancies from forming, however, neither reference describe, how to eliminate nitrogen vacancies once they have formed. The Examiner's attention is directed to the fact that when

Moustakas uses the word 'reduce' in Col. 4, line 40, he is clearly using it to mean 'form fewer' nitrogen vacancies in the first place, and not to mean to 'recover from damage' due to nitrogen vacancies by taking a device that already has many nitrogen vacancies and somehow reducing the number of nitrogen vacancies in it.

The Examiner argues that applying Moustakas' technique to any process in which there was a problem associated with nitrogen vacancies would have been obvious to the skilled person.

By an analogy [to this USPTO position], this seems to be a little like saying that a physician would find it obvious to use a measles vaccine (a weakened but live version of the measles virus) to treat a person who had actually caught measles. We don't think this treatment would work. It might make the patient's condition worse. We think that the skilled artisan in any field would be disinclined to use a preventive measure to treat a problem that had actually occurred and was accordingly no longer preventable.

Closer examination of Moustakas' technique does not reveal any other description/recitation that might suggest the present invention. The description of Moustakas' technique refers to a nitrogen plasma overpressure mentioned in Col. 5, lines 46-48. These lines are part of a description of a process for forming a GaN epitaxial layer on a sapphire substrate. In contrast, the present invention is concerned with what happens to a nitrogen-containing compound semiconductor layer after it has been formed.

In the process Moustakas describes, the surface of the sapphire (Al_2O_3) substrate is nitrided to replace oxygen atoms with nitrogen atoms and create a surface layer of aluminum nitride (AlN). The nitridation is effected by sputter-etching, which is a type of dry etching, but this dry etching process is quite unlike the dry etching process in the independent claims of the present application. It does not remove part of a compound semiconductor layer; instead, it alters the surface chemistry of an insulating layer. Nor does it cause damage by removing nitrogen; instead, it adds nitrogen.

Next, a buffer layer of partly or wholly amorphous GaN is deposited on the AlN surface layer; the buffer layer is annealed so that it crystallizes; then an epitaxial layer of crystalline GaN is grown on the crystallized buffer layer. The epitaxial layer may be doped with n-type or p-type impurities, or intentionally autodoped with nitrogen vacancies (Col. 6, lines 50-51). In another embodiment, Moustakas describes a chloride transport process in which nitrogen vacancies can be intentionally formed for autodoping (Col. 15, lines 7-18).

There is a particularly wide gap between Moustakas' teaching of the positive use of nitrogen vacancies for autodoping and the use of nitrogen plasma treatment in the present invention to remedy damage by eliminating nitrogen vacancies.

While Moustakas teaches a method of avoiding the formation of nitrogen vacancies, the claimed invention is concerned with ***recovering from nitrogen vacancies that have already been formed as a result of a dry etching process***. Claims 1, 5 and 10 make this distinction clear. Applicants respectfully submit that Moustakas nowhere teaches or reasonably suggests that

nitrogen vacancies might form as a result of dry etching or that nitrogen plasma treatment might be useful for recovering from such nitrogen vacancies.

Claims 1, 5 and 10 are allowable over admitted prior art and Moustakas.

Claims 3 6, 8, 11, 13 and 15 variously depend from claims 1, 5 and 10, and are allowable as being dependent from an allowable claim.

Applicants respectfully request reconsideration and withdrawal of the rejection of Claims 1, 3, 5, 6, 8, 10, 11, 13 and 15 under 35 U.S.C. § 103(a) as being unpatentable over admitted prior art and Moustakas.

35 U.S.C. § 103(a) Rejection based on admitted prior art, Moustakas and Lee

2. Claims 2, 7 and 12 are rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over admitted prior art in view of Moustakas and Lee (U.S. Patent No. 6,762,083). Applicants respectfully traverse this rejection.

Claims 2, 7 and 12 variously depend from Claims 1, 5 and 10 and are allowable as being dependent from an allowable claim.

Further, Lee describes a method for manufacturing an AlGaN/GaN HFET device which is capable of easily forming a fine gate electrode. Lee fails to supplement the deficiencies of Moustakas because Lee fails to teach or reasonably suggest that nitrogen vacancies might form as a result of dry etching or that nitrogen plasma treatment might be useful for recovering from such nitrogen vacancies.

Applicants respectfully request reconsideration and withdrawal of the rejection of Claims 2, 7 and 12 under 35 U.S.C. § 103(a) as being unpatentable over admitted prior art in view of Moustakas and Lee.

35 U.S.C. § 103(a) Rejection based on admitted prior art, Moustaka and Gilbert

3. Claims 4, 9 and 14 are rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over admitted prior art in view of Moustakas and Gilbert (U.S. Patent Application Publication No. US 2002/0072223 A1). Applicants respectfully traverse this rejection.

Claims 4, 9 and 14 variously depend from Claims 1, 5 and 10 and are allowable as being dependent from an allowable claim.

Further, Gilbert describes a method of fabricating a ferroelectric memory device. Gilbert fails to supplement the deficiencies of Moustakas and Applicants' admitted prior art because Lee fails to teach or reasonably suggest that nitrogen vacancies might form as a result of dry etching or that nitrogen plasma treatment might be useful for recovering from such nitrogen vacancies.

Applicants respectfully request reconsideration and withdrawal of the rejection of claims 4, 9 and 14 under 35 U.S.C. § 103(a) as being unpatentable over admitted prior art in view of Moustakas and Gilbert.

New Claims

3. Newly added dependent claims 19 -21 depend, respectively, from claims 1, 5 and 10, and are allowable as being dependent from an allowable claim.

Further, these claims recite that the nitrogen plasma step is carried out at a temperature of less than 40° C, which admitted prior art, Moustakas, Lee, and/or Gilbert nowhere teach or reasonably suggest.

4. Applicants respectfully traverse the rejection of Claims 16-18 under 35 U.S.C. 112. As applicants' state at page 14, the treatment can be conducted at 40 degrees C. but that the conditions can be modified. In applicant's view, 40 degrees C. supports the phrase less than 100 degrees C. Moreover, it is clear that the specification indication is that the treatment temperature is a condition which applicants have indicated can be modified. As neither 100 degrees C nor 40 degrees C is a temperature contemplated or expressed in the references cited by the Examiner-- for the method of the claims, --applicants' claims and specification should be given broad latitude as to the interpretation of this recitation.

Conclusion

5. All of the stated grounds of rejection have been properly traversed. Applicant therefore respectfully requests that the Examiner reconsider all presently outstanding rejections and that they be withdrawn. Applicant believes that a full and complete reply has been made to the outstanding Office Action and, as such, the present application is in condition for allowance.

If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is hereby invited to telephone the undersigned at the number provided.

An early allowance is respectfully requested.

August 2, 2006

Respectfully submitted,

By 
Marina V. Schneller
Registration No. 26032

VENABLE LLP
P.O. Box 34385
Washington, DC 20043-9998
Telephone: (202) 344-4000
Telefax: (202) 344-8300
Attorney/Agent for Applicant